Advanced Structural Health Monitoring

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Lead Center:LaRC
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This subtopic seeks new and innovative technologies in structural health monitoring (SHM), integrated vehicle health management (IVHM) systems, their corresponding analysis tools, and smart materials. Advanced structural composites and sensors with the potential to enable or enhance distributed damage detection for aerospace vehicles and spacecraft are sought. Example systems should allow for detection of damage states including corrosion, electrostatic discharge, delamination, cracking, microcracking, porosity, fiber breakage, impact damage, micrometeoroid orbital debris impacts on orbit, and general material property degradation due to aging. The innovative introduction of smart aspects to composite structures, for example, autonomous healing, shape memory, or piezoelectricity, is of interest. Such structures could allow for the realization of the mass reduction that composite materials have promised for spacecraft through enhanced damage tolerance. The addition of multi-functionality would be an asset towards improving overall system efficiency.

NASA is evaluating advanced composite structures due to their relatively high strength, light weight, and potential low production cost. Currently, damage tolerance concerns require that much thicker and heavier composite structures be manufactured to compensate for potential damage, and therefore the weight savings that composites promise has not yet been achieved. Smart sensor systems and smart structural composites could address this issue of damage tolerance, thereby allowing composites to be far lighter. Development of advanced technologies is required to improve the capability to better detect damage during manufacture and lifetime. Determining the extent of damage and/or autonomous healing of damage will also reduce the complexity of composite maintenance and increase performance lifetime and reliability.

This STTR seeks to enable the creation of smart composite systems and smart sensor systems for extended structural life monitoring and/or self-repair. Primary material systems for this STTR can include metals, but it is highly desirable to target carbon composite structures. Inclusion of smart or enhanced materials such as piezoelectric, shape memory, and self-healing will be highly advantageous. Other potential sensors are: Surface Acoustic Wave (SAW)-based sensors, passive wireless sensor-tags, flexible sensors for highly curved surfaces direct-write film sensors, and others. Sensor systems can include sensors that can be applied post-manufacture of the structure. All systems will provide information about location and extent of the structural deficiency. It is not required but considered highly advantageous to directly relate to a measurable material property such as remaining material strength, density, etc.

Suitable target structures include but are not limited to primary and secondary structures, including vehicle, habitat module, and pressure vessel structures. Target structures may be relevant to either existing or future aerospace vehicles and spacecraft. SHM and IVHM systems applicable to the International Space Station are especially of interest, though the scope of the solicitation is not limited to this application. This subtopic is not intended for materials coupon-level work only; proposed systems should have a targeted demonstrator structure identified as a deliverable.

In Phase I, composite samples or prototype sensor systems will be fabricated and tested to demonstrate basic functionality of the material or sensor system. The targeted demonstrator structure will be identified, and critical test environments and associated performance predictions will be defined relative to the final operating environment. Deliverables include composite samples, sensors, associated test data, predictions, and lessons learned.

In Phase II, while full-scale demonstrators are not required, scaled-up systems will be built in application-appropriate geometries. Demonstrators will be tested in a simulated operational environment for demonstrate of performance in critical areas. Further scale-up requirements will be defined, and performance predictions will made for subsequent development phases. Deliverables will include samples and the associated test data, sensor hardware and predictions.